Appendix D

Runoff, Water Storage Layer Infiltration, Bio-intrusion, and Lateral Drainage Calculation

D.1 ADJUSTED PRECIPITATION, RUNOFF, AND LATERAL DRAINAGE CALCULATION

Purpose:

Determine the percolation through the clay barrier layer using percolation through the silt loam surface material and infiltration resulting from bio-intrusion as the driving head and accounting for lateral drainage provided by the drainage layer

Methodology:

Percolation through the silt loam was determined using SoilCover™. Two weather scenarios were modeled. The base case scenario used 10 years that represented average conditions for the site the years modeled were 1967-1976. The extreme scenario included four years with precipitation above the 90th percentile modeled consecutively. The years modeled for the extreme scenario were 1957, 1962, 1963and 1995.

Precipitation for the fourteen-year period modeled was adjusted to account for runoff using the U.S. Soil Conservation Service (SCS) method. The SCS curve number (CN) was adjusted to account for the slope of the cover using the method developed US EPA for the HELP model. The runoff determined by this method was used to reduce the precipitation into the SoilCover™ models.

Infiltration resulting from burrowing animals was determined using assumptions agreed to by the regulatory agencies. These include one burrowing animal in the cover. The burrow consisted of one 20 cm diameter hole in the surface of the cover that drains an area ten times the area of the hole. The animal was assumed to have burrowed to the top of the bio-intrusion barrier with all precipitation from the drained area percolating to the clay barrier layer.

Water removed from the system by the drainage layer above the clay barrier was determined using the Dupuit flow equation. Assumptions associated with the Dupuit equation are given below.

- The hydraulic gradient is equal to the slope of the cover

- The lateral drainage layer is saturated over the depth of the flow

- The hydraulic head is constant for any given day

Calculations:

Runoff was calculated using the SCS Curve Number Method given by the equation (D-1):

$$Q = \frac{(P - 0.2\,S)^2}{P + 0.8\,S} \tag{D-1}$$

Where,

Q = runoff (in)

P = precipitation (in)

S = potential maximum retention

   = (1000/CN) - 10

CN = curve number

The CN is determined from tables provided by the SCS. The curve number used was 79 as determined for a pasture or range with no mechanical treatment, in poor condition (less than 50% ground cover) with hydrologic group B soils. This curve number was adjusted to account for the slope of the cover using the equation (D-2) developed for use in the HELP model.

$$CN_a = 100 - (100 - CN)\left(\frac{L*^2}{S*}\right)^{CN^{-0.81}} \tag{D-2}$$

Where,

L* = standardized dimensionless length, (L/500, ft)

S* = standardized dimensionless slope, (S/0.04, ft/ft)

For the Curve Number Method, the runoff begins after an initial amount of precipitation has fallen. This amount of precipitation is called the initial abstraction, I_A, and is given by, $I_A = 0.2\ S$

The infiltration through the upper soil layers was determined using SoilCover^{TM}. The precipitation entered into SoilCover^{TM} was adjusted to account for the runoff by subtracting the calculated runoff from the recorded precipitation. To prevent double counting runoff, storm events were adjusted to prevent SoilCover^{TM} from calculating runoff.

For the calculation of lateral drainage, the infiltration calculated by SoilCoverTM was added to the infiltration resulting from bio-intrusion. By agreement with the regulatory agency, the calculation was conducted assuming one burrow in the cover with a diameter of the hole being 20 cm draining an area ten times that diameter. The calculation was conducted using the following equation (D-3).

$$A_D = \frac{\pi (D_H \times 10)}{4} \tag{D-3}$$

Where, D_H = diameter of the burrow opening

The volume of precipitation infiltrating to the clay barrier is determined by multiplying the area drained by the precipitation as given by the equation: $V_I = P \times A_D$, where P is the daily precipitation.

The infiltration per unit area of the cover was determined from: $I_{avg} = V_I / A$, where A is the area of the cover.

Hydraulic head supporting lateral drainage was the sum of the infiltration from the SoilCoverTM model and from bio-intrusion. Lateral drainage through the drainage layer was calculated using the Dupuit equation (D-4).

$$q' = -\frac{1}{2}K\left(\frac{h_2^2 - h_1^2}{L}\right)$$

(D-4)

Where,

q' = water drained from the system

K = saturated hydraulic conductivity of the drainage layer

h1 = hydraulic head at the crest of the crest of the cover

= L * tan α

α = slope of the cover

L = horizontal length of the cover

h2 = hydraulic head at the drain

The slope of the cover used in the calculation was based on the minimum slope determined in "Landfill Compaction/Subsidence Study" (EDF-ER-266). The result of this equation represents drainage per unit length of the perimeter of the cover. The drainage was averaged over the area of the cover by multiplying the q' from the Dupuit equation by the perimeter and dividing the product by the area of the cover.

Results of these calculations for the base case and extreme scenarios are given in Tables D.2 and D.3 respectively. The variable used in the calculations are given in Table D.1

Table D-1. Variables used in calculation of runoff, bio-intrusion and lateral drainage.

Variable	Value	Source
Properties of Cover		
Length	264 m	[Drawing C-304 dated 4/16/01]
Width	236 m	[Drawing C-304 dated 4/16/01]
Slope Length	122 m	[Drawing C-304 dated 4/16/01]
Slope Angle	3 %	EDF-ER-266 – Subsurface Consolidation Calculation
Properties for Runoff Analysis		
CN=	79	SCS CN tables
Adjusted CN =	79.10	Calculated
Max Retention (S)	67 mm	Calculated
Initial Abstraction (I_A)	13.5 mm	Calculated
Properties for Bio-Intrusion Analysis		
Hole Diameter	20 cm	Regulatory Agreement
Area Drained	3.14 m^2	Regulatory Agreement/Calculated
Area of Cover	62,400 m^2	Calculated
Properties for Lateral Drainage Analysis		
K_{sand}	1.00E-02 cm/s	